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Abstract

This note gives a brief survey of main theoretical and empirical issues with respect to the NAIRU concept. According to modern labour market literature NAIRU is defined as the rate of unemployment at which inflation stabilizes in the absence of any wage-price surprises. Conventional thinking about the equilibrium unemployment rate assumes that in the long run NAIRU is determined solely by supply side factors of the labour market. We show that quite complex adjustment dynamics may arise even in simple log-linear wage-price models. Furthermore we provide a survey on a number of "hysteresis-mechanisms" which could lead to permanent shifts of equilibrium unemployment over time, implying that an unique long run NAIRU may not even exist.

In addition to theoretical issues we refer to two serious problems which might arise with empirical applications of the NAIRU concept. First various empirical studies suggest that results highly depend on model specifications. Second a considerable amount of statistical imprecision is inherent in the results obtained from empirical estimates.

For these reasons, we argue, that policy conclusions drawn from the NAIRU concept must be judged with utmost care, particularly since in many countries a number of labour market measures as well as monetary policy are based on this concept.

Keywords

NAIRU, hysteresis mechanisms

JEL-Classifications

E24, C51

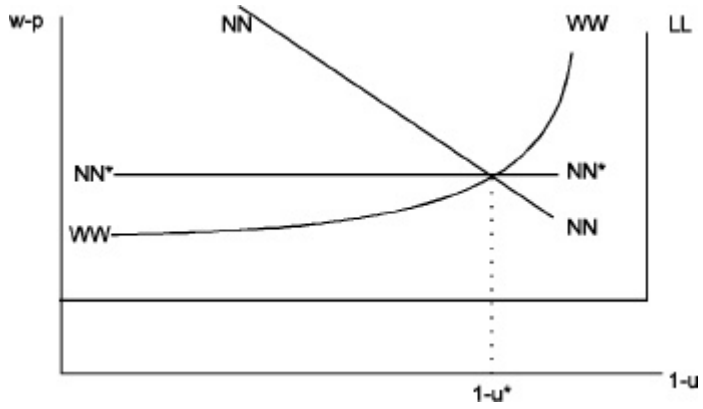
Contents

I. Conceptual Issues

a: Basic Concept

The conventional framework for thinking about unemployment in an imperfectly competitive world nowadays pictures the labour market equilibrium in terms of the intersection between a downward-sloping aggregate labour demand curve and an upward-sloping wage setting curve in real wage-employment space (c.f. Bean, 1994).

Figure 1:



LL is the competitive labour supply schedule, for simplicity, drawn assuming a common reservation wage across the whole labour force and totally inelastic labour supply above that level. The wage-setting curve WW represents the real wage that emerges, at any given level of employment, from wage bargaining or the operation of efficiency wage mechanisms. The labour demand schedule (or more accurately, the price-employment schedule) NN depicts firms' optimal price and employment decisions, given the nominal wage they face and their existing stock of capital. In the long run, when capital can be adjusted, and with constant returns to scale, the long-run labour demand schedule can be drawn as NN*.

The above framework has also been phrased in terms of a "Battle of the Mark-Ups" reflecting the general idea that in the short-run it is inflation (or a current account deficit), but in the long-run it is unemployment which reconciles competing claims on overall output.

A simple formal exposition may help to clarify the points.

Firms:

(1) $$p - w^e = b_0 - b_1 u$$

set prices as a mark-up over expected wages, with β_0 denoting "price-push" factors (e.g., oil shocks, productivity slowdown), and with the mark-up depending (at least in the short-run) upon the state in the labour market.

Workers

(2) $w - p^e = g_0 - g_1 u$

demand wages in relation to expected prices, with $g_1 > 0$ because of union bargaining or efficiency wage considerations, and with g_0 denoting "wage-push" factors (e.g. unemployment benefits, union power).

Solving for *u* yields

(3) $u = (b_0 + g_0) / (b_1 + g_1) - 1/(b_1 + g_1) [\, p - p^e + w - w^e \,]$

Clearly, when there are no wage-price surprises

(3') $u = (b_0 + g_0) / (b_1 + g_1) = u^*$

with u^* denoting the no-surprise equilibrium rate of unemployment.

In order to pin down the underlying inflation-unemployment trade off, assume that real wages equal expected real wages and expected inflation equals last year's inflation, to obtain

(4) $Dp = q_1 (u^* - u)$

This is a standard accelerationist Phillips-Curve giving rise to a vertical aggregate supply schedule in inflation/employment space. Inflation will only remain unchanged in this setting, when actual unemployment equals u^*. Thus, the effects of aggregate monetary and fiscal policy, as well as of other types of demand shocks, are in the long-run constrained by this fundamental supply-side relationship. From this perspective, the only sustainable way to bring down unemployment is to reduce u^*.

The model is usually closed by introducing a conventional downward sloping aggregate demand schedule whereby lower prices elicit higher demand via real balance effects (and/or lower interest rates, improved competitiveness). Thus, demand disturbances may lead to cyclical unemployment, i.e., deviations of actual unemployment from its equilibrium level as defined above.

In the simple framework outlined above, movements in unemployment can be caused by shifts in aggregate demand giving rise to cyclical unemployment, and by shifts in the price or wage-setting schedules which change equilibrium unemployment.

The textbook story claims that negative (positive) demand disturbances may temporarily push actual unemployment above (below) its equilibrium level, but over the medium term the ensuing process of disinflation (inflation) will inevitably drive unemployment back to equilibrium. The conventional story then continues to argue that the degree of nominal inertia is simply not high enough to explain the sustained increase in unemployment in Europe. Thus, the story concludes there must have been unfavourable shifts in the fundamental supply-side determinants of the NAIRU. The policy implication then, of course, is to press for supply-side reforms.

However, despite considerable efforts, it has been hard to identify changes in the basic determinants of equilibrium unemployment large enough to account for the observed trend increase in actual unemployment. Consequently, the alternative hypothesis has been put forward that unemployment may be strongly dependent on its own history ("hysteresis"). According to this view, current equilibrium unemployment is not independent of past actual unemployment, because of endogenous mechanisms that tend to translate movements in actual unemployment into changes of equilibrium unemployment. Obviously, the presence of such mechanisms blurs the simple-minded distinction between demand and supply factors because demand shocks end up having longer-term supply consequences.

Before discussing the hysteresis issue in somewhat more detail, we note in passing that even in a standard (log)-linear NAIRU model the dynamic response to shocks may be more complex than conventional theorizing asserts. This can be shown by combining the aggregate-supply-schedule

(4) $Dp = q_1 (u^* - u)$

with a standard AD-schedule incorporating quantity theory and Okun´s law

(5a) $m - p = y - v$

(5b) $y^* - y = l (u - u^*)$

Assuming velocity to be constant, taking the first derivative results in

(6) $Du = 1/l (p - Dm)$

Obviously, the steady-state solution for equations (4) and (6) has inflation equal to nominal money growth and actual unemployment equal to equilibrium unemployment. However, it should also be noted that (4) and (6) render a system of Volterra - Lotka type equations, where the eigenvalues of the characteristic equation are pure imaginaries; thus, any disturbance to the steady state results in perpetual cycles in the inflation-unemployment space. (van der Ploeg, 1993).

Another interesting implication arises when the impact of unemployment on (log) wages is assumed to be non-linear. Recall in that respect that the relevant relationship is known as the Phillips curve rather than the Phillips line. Suppose, for example, that the inflation rate is driven by the divergence between the logarithm of unemployment and the logarithm of the natural rate.

(4') $Dp = q_1 (\log u^* - \log u)$

Then, even if the log of unemployment is on average equal to the log of the natural rate, the average level of unemployment will be larger the greater the variance of unemployment[1]. This result thus produces the intuitively appealing result that countries which conduct stabilization policy better will have a lower average unemployment rate. (Fischer 1994).

b: Hysteresis and the Interaction between Demand and Supply-Side Policies

The distinguishing feature of a process characterized by hysteresis is that the behaviour of the process cannot be described by reference to state variables alone; instead in addition to state variables the past history of the process has to be invoked in order to explain its behaviour. Loosely speaking, the hysteresis hypothesis suggests that the experience of the journey may, by itself, lead to alternating the route and delaying arrival and possibly even to a change in the final destination. In economic terms this means that the attained equilibrium position of an economic system depends on its own history and may therefore exhibit some degree of indeterminacy.

The following simple technical exposition may be helpful in clarifying how traditional economic thinking about the tradeoff between unemployment and inflation is altered when the evolution of unemployment is subject to hysteresis effects. As a starting point, consider the following general formulation of the Phillips curve:

(7) $p = p^e + q_1 (u^*-u)$

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[1] Suppose that (log u - log u*) is normally distributed with mean zero and variance σ^2.
Then E(u) = exp (log u* + 1/2 σ^2).

where p and p^e denote, respectively, the actual and expected rates of inflation and u is the rate of unemployment. Equilibrium unemployment (the so-called NAIRU) corresponds to the steady-state situation when actual inflation is equal to expected inflation, so that $u = u^*$. Then, u^* itself is usually assumed to be determined by a set of structural factors affecting the demand and supply side of the labour market, but to be invariant with respect to business cycle conditions. Thus denoting the relevant explanatory variables by X.

(8) $$u^* = bX$$

The possibility of hysteresis arises when equilibrium unemployment in a given period also depends on actual unemployment in the past, as e.g.

(9) $$u^*(t) = a\, u(t-1) + bX$$

In a steady-state, where actual inflation is equal to expected inflation and unemployment is constant, equilibrium unemployment is now given by

(10) $$u^* = bX/(1-a)$$

As can be immediately seen from the above equation, when last period's actual unemployment is fully translated into equilibrium unemployment in the next period (the case $\alpha=1$), then steady-state equilibrium unemployment is no longer uniquely defined. Any change in actual unemployment, e.g. brought about by macroeconomic policies, would also alter the NAIRU by the same amount; such a situation has been labelled as pure hysteresis. When actual unemployment feeds only partly into future equilibrium unemployment (the case $0 < \alpha < 1$) there is persistence in unemployment in the sense that the NAIRU evolves only slowly towards its steady-state level. In such a situation, the short-run NAIRU - meaning the level of unemployment at which there is no current upwards or downwards pressure on inflation - always lies between steady-state equilibrium unemployment and last period's actual unemployment. This carries the unpleasant implication that high unemployment can only be slowly reduced to its long-run equilibrium level ("speed limits") if temporary increases in inflationary pressures are to be avoided. However, the dynamic trade-off between unemployment and inflation is likely to be more complicated than in the simple example outlined above. For example, unemployment may cycle after a one-off shock before it converges to its steady-state level. Thus, it can be the case that in the wake of a shock the short-run NAIRU even exceeds actual unemployment, implying that it takes additional unemployment to get inflation down in the short-run. Furthermore, persistence effects may be asymmetric, in the sense that upwards movements in actual unemployment are more easily translated into higher short-run equilibrium unemployment than vice versa.

The conventional way to introduce hysteresis mechanisms into the analysis is by adding into the wage equation an additional term denoting the change in unemployment

(11) $w - p^e = g_0 - g_1 u - g_2 Du$

where in the case of pure hysteresis it is only the change term that matters. Thus, most explanations for hysteresis generating mechanisms focus on the behaviour of labour market participants, changes in their productive capacity caused by unemployment, and on the resulting consequences for wage bargaining and the matching process between workers and jobs. The general idea is a distinction between insiders and outsiders in the labour market carrying different weights in the wage bargaining process. When unemployment by itself tends to reinforce the outsider status of those affected, then the moderating impact of higher unemployment on wages will vanish over time. The same result will emerge when the (employed) insiders have sufficient market power, probably fostered by employment protection regulations, to safeguard their income claims and employment status against outside labour market conditions. Finally, a growing number of unemployed outsiders may create information distortions in the labour market, thereby making it more difficult to form suitable matches between workers' characteristics and the skill requirements of potentially available jobs.

The hysteresis generating mechanism that has gained most attention operates through changes in *human capital* in a broad sense. According to this view, prolonged periods of unemployment may lead to a deterioration of skills and important attitudinal aspects of the work ethics and motivation of individual job seekers. And, obviously, when out of work, there are no opportunities for learning-by doing and on-the-job training. The loss of skills during unemployment may also lead to duration dependence in the probability of leaving unemployment, i.e. the likelihood that unemployed workers move to employment is likely to fall as the duration of unemployment increases. Furthermore, discouragement effects may over time loosen the attachment to the work force resulting in reduced job search intensities.

Even when the quantitative importance of human capital depreciation is considered to be fairly small, the mere fact of being out of work for a long time may convey a negative signal about worker's productivity to potential employers. Consequently, the long-term unemployed may over time receive fewer and fewer job offers and may, finally, be even regarded as *unemployable*. The resulting disattachment from the labour market implies that the long-term unemployed may exert little or no downward pressure on wage increases. Moreover, a growing number of inefficient job-seekers in the pool of the unemployed may reduce the speed by which vacant jobs can be filled by suitable candidates.

When specific skills are an important aspect of the employment relation, involuntary separation from a job may imply long waiting periods for re-employment; and when the loss

of specific skills and the associated wage premium eventually has to be accepted, specific capital no longer provides a buffer between productivity and the value of employment elsewhere or non-employment, so turnover from new jobs, probably associated with recurrent unemployment, may be rapid. Loosely speaking, the argument is that any negative shock to employment is likely to produce another cohort of *restarting* workers - quite similar in labour market behaviour of young workers - and, thereby, raise equilibrium unemployment.

Another major strand of reasoning puts the emphasis on the wage-bargaining behaviour of the employed insiders and on the role of adjustment costs. For example, when unions bargain mainly on behalf of the incumbent workforce, then a temporary adverse shock to employment will tend to perpetuate itself, because real wage demands are adapted to the now smaller number of employed insiders. More generally speaking, shifts in the employment composition in favour of groups facing little risk of unemployment may affect the overall bargaining stance of unions and thus reduce the wage-moderating impact of a given rate of unemployment.

For insider effects to persist, the employed insiders must command some degree of market power. This could stem from several sources such as training costs or statutory seniority systems, but also various forms of job security legislation. While the resulting reduction in turnover may well be in the interest of both the firm and the workers, the crucial point with regard to the persistence issue is that turnover costs may make it difficult for outsiders to provide efficient competition for jobs.

In addition to the supply side mechanisms described above there may also exist a number of important demand side effects which could lead to a change in equilibrium unemployment. The simple model below illustrates possible demand side effects which could play a significant role. Equation (1) describes price setting of firms under imperfect competition. Extending the basic model allows to illustrate possible "price push" factors whereby product demand changes could have an impact on equilibrium unemployment.

Consider the following model of the labour demand curve, proposed by Lindbeck/Snower (1994):

Assume a fixed number of identical firms (F) each maximizing its present value of profits (PV):

(12) $$PV = S_t \, d^t \, (P_t \, q_t - W_t n_t - R_t \, k_t)$$

subject to an aggregate product demand function:

(13) $$Q = (P/P, \, X/P, \, A)$$

a conjecture function describing the imperfectly competitive interactions between the firms

(14) $d(Q^e-q)/dq = c-1$ [2]

the firms production function

(15) $q = h(n,k)$

and a predetermined nominal wage *W*

Here *P* is the product price, P an aggregate price index, *X* stands for nominal endowments, A is an exogeneous shift parameter, *q*, *Q* is the output of the individual firm and aggregate output respectively and *c* describes the firm´s interactions with it *s* rivals.

The first order conditions are:

(16a) $$\left(1-\frac{c}{h.F}\right)h_n(n_t,k_t) = W_t / P_t$$

(16b) $$\left(1-\frac{c}{h.F}\right)h_k(n_t,k_t) = R_t / P_t$$

where *h* is is the price elasticity of product demand.

This basic model which is commonplace in microeconomic theory allows to describe a broad spectrum of possible channels whereby product demand could have a persistent impact on (un)employment.

First, if wages and prices were sluggish changes in product demand would have a direct impact on employment. However, this standard Keynesian argument may be of importance primarily in the short run. New Keynesian theories (menu cost theory, theory of near rationality, wage-price staggering theory) provide a firm microeonomic basis to explain the origin of wage-price stickiness.

In addition to the traditional Keynesian explanations, equations (16a,b) point to a number of plausible channels which could lead to persistent changes in labour demand due to changes in product demand.

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[2] The equation depicts the firms expectations about the rivals reaction to an increase in it s own production by one unit (q); the value of the parameter c describes the competitive behaviour of the market (i.e.: c=0 ≈ perfect competition; c=F ≈ Cartel behaviour; c = 1 ≈ Cournot behaviour).

So, if the marginal product of labour and (or) capital change[3] in response to exogenous shifts in product demand this would lead to a change in labour demand. Government spending on industrial infrastructure investment generating an increase in labour producitvity and thereby shifting the labour demand curve outwards constitutes one example of a corresponding shift in labour demand. As this mechanism operates especially in the long run it has been cited as a possible explanation of long run movements of equilibrium unemployment as relatively low unemployment rates in the OECD area during the 1950´s and 60´s coincided with a significant build up of industrial infrastructure, whereas the general slowdown of infrastructure investment since the mid 70s was accompanied by a significant rise in OECD unemployment.

Shifts in product demand could lead to changes in the competitive interactions between firms via the intensity of competition (c) or the number of firms (F). In line with a long standing tradition it can be argued that oligopolists may behave more competitively in a boom, so that a rise (fall) in product demand would shift the labour demand curve outwards (inwards). Furthermore Pagano (1990) and Snower (1983) have shown that increases in product demand can induce the entry of new firms, which would shift the labour demand curve by influencing product market competition. These arguments could in part explain the different evolution of unemployment in Europe and the United States. The greater ease of entry of firms in the US might for example explain the higher reductions in unemployment achieved in the US compared to Europe during the recent recovery.

If movements of product demand influence the real user cost of capital (the real interest rate, R/P), this would lead to a corresponding adjustment of the capital stock which would shift of labour demand curve[4]. Product demand may influence the real interest rate via changes in the risk premium on investment (as argued by Greenwald/Stiglitz 1988) or via monetary policy. In addition, Phelps (1994) pointed to a number of channels whereby changes in the real interest rate may shift both the labour demand and the wage setting schedule. The effect of the real interest rate on labour demand could possibly explain the adverse employment effect of high budget deficits and rising debt ratios in many OECD countries that might have induced a rise of real interest rates and thereby may have shifted the labour demand curve inwards.

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[3] An increase in h_n or h_k at a given real wage (W/P) under the standard assumptions of $h_n>0$, $h_{nn}<0$, $h_{nk} > 0$ leads to an increase in employment.

[4] Holding the real wage constant the effect of a change of the real rate of interest can be obtained by total differentiation of (16a) and (16b) , set N = F.n and solving for employment:

$$\frac{dN}{d(R/P)} = \frac{h_{nk}}{[h_{nn}h_{kk} - (h_{nk})^2]\left(1 - \frac{c}{hF}\right)}$$

Finally, changes in the composition of demand may induce a move of the aggregate price elasticity of product demand *(h)* which, again, would lead to a shift in the labour demand curve.

II. Measurement Issues

a) Time Series approaches

The discussion in Section I indicated, that there seems to exist a broad consensus among economists that there exists, at least in the short run, a unique "equilibrium unemployment rate" i.e. the "NAIRU" which is consistent with stable inflation. In practice rules for the conduct of monetary policy, or programmes to reduce unemployment are guided by empirical estimates of the NAIRU. The construction of estimates of the NAIRU, however, suffers from the fundamental problem that the NAIRU is an unobserved variable, so that there exists leeway for a broad range of plausible methodological approaches for the estimation of the equilibrium unemployment rate.

A widely used method to construct estimates of the NAIRU relies on time series methods which are based solely on data on the unemployment rate. Univariate methods proceed by decomposing the unemployment rate into a deterministic and a stochastic component. The deterministic component of the series is then interpreted as the "equilibrium unemployment rate" whereas the stochastic component represents the "cyclical" development of the unemployment rate. In order to obtain an estimate of the "NAIRU" it has to be ensured that the deterministic part of the unemployment rate is uncorrelated to inflation. This approach has various advantages: It is easy to construct estimates of the NAIRU and theoretical issues (i.e. misspecification of the "model") can be avoided to a large extent.

The simplest univariate specification assumes that the unemployment rate is a realization of a stationary process, with its expectations being the (time-constant) NAIRU.

(17a) $$u_t = \sum_{i=1}^{p} f_i u_{t-i} + e_t$$ where the random variable $e_t \approx$ iid with mean 0

satisfying

(17b') $$E[u_t] = \bar{u}$$

(17b'') $E[u_t - u_{t-1}] = 0$

Note that this specification would be in accordance with the basic model described in section I, which would , in the absence of any changes of structural factors of the labour market, imply that the equilibrium unemployment rate is constant over time. A look at the OECD unemployment rates reveals, however, that actual unemployment rates exhibit considerable deviations from the long run mean over time. According to the discussion in section I this could be due to changes in the structural factors of the labour market, so that the equilibrium unemployment rate shifts from time to time. This possibility is taken into account when constructing estimates of the NAIRU which allow for "breaks" in the series, so that (17b) becomes:

(18) $E[u_t] = u_i$ if $t_{i-1} < t \leq t_i$; i = 1,....,I

A problem arises within this model as the breaks are treated as being known with certainty. In practice however, it is difficult to determine the exact timing when the NAIRU might switch from one regime to another, so that an additional source of imprecision is added to these estimates.

However since the 1980s a growing number of empirical studies suggests that the equilibrium unemployment rates, especially in Europe, may be described by nonstationary time series, i.e. that they follow a stochastic trend so that

(19a) $E[u_t] = E[u_{t-1}] + h_t$

or

(19b) $u_t - u_{t-1} = a + h_t$

the parameter *a* representing the deterministic and h the stochastic component of the trend.

This implies that an "equilibrium" value does not exist to which the unemployment reverts in the long run. This specification of the NAIRU concurs with the theoretical view, described in Section Ib, that hysteresis factors are at work at the labour market, i.e. that the NAIRU depends on the historical evolution of actual unemployment.

Structural Time Series Models as proposed by Harvey (1989) represent an appropriate methodological tool to construct estimates of the (unobserved) stochastic components of unemployment rates. These models assume, that the NAIRU may be driven by simple but flexible stochastic processes. A standard specification of a univariate structural time series model of the NAIRU looks as follows:

(20a) $u_t = u^*_t + uc_t + i_t$

(20b) $u^*_t - u^*_{t-1} = a_{t-1} + e_t$

(20c) $a_t = a_{t-1} + \eta_t$

where u is actual unemployment, *u** represents the trend unemployment rate, which may then be interpreted as the NAIRU, *uc* is the cyclical unemployment rate, which follows a stochastic cycle.

b) Wage-Price Models

The fundamental drawback of the time series approach for the estimation of the NAIRU is that it is atheoretical in the sense that it does not provide causal explanations for the development of the "equilibrium" unemployment rate. Estimates based on the univariate time series methodology therefore form no sound basis for policy interventions as they leave the interactions between the economic variables indeterminate.

Econometric models based on the theoretical model described in Section I take the interdependence between economic variables into account. Empirical results obtained from these models thus allow for causal interpretations of the NAIRU estimates. In contrast to time series models movements of the NAIRU are "explained" by various labour market variables (i.e. wage or price pressure elements as described in Section I) which are inserted into the empirical models.

One commonly applied method to estimate the equilibrium unemployment rate is based on the wage equation described in section I (11), written in log-linear form:

(21)

$$\Delta(\log(w_t) - \log(p_t)) = b_0 + b_1(L)(\log(p_t) - \log(p_t^e)) - b_2(U_t - NAWRU_t) + b_3\Delta U_t + b_4 \log(x_t) + b_5 \log(Z_w) + w_t$$

where NAWRU represents the equilibrium unemployment rate, x depicts productivity and Z_w are variables representing wage pressure elements (such as unemployment benefits, taxation, labour market mismatch, employment protection etc.) and the change of the unemployment rate is inserted to capture possible hysteresis effects. Thus, the NAIRU may move over time due to changes in wage pressure elements or as a consequence of hysteresis effects. As this specification relates wage inflation rather than price inflation to movements of the unemployment rate corresponding estimates of the equilibrium unemployment rate are referred to as the NAWRU (Non Accelerating wage rate of unemployment). By imposing the long run homogeneity restriction, namely that real wage growth must be proportional to productivity growth, this specification implies that it is possible to analyze the long run equilibrium properties of the equilibrium unemployment rate.

In order to construct an estimate of the NAWRU a model for inflationary expectations has to be developed for the estimation of the equation. A commonly used approach is to use lagged inflation rates as a proxy for "price surprises". Alternatively some consensus or median forecast of inflation can be used in order to depict "expected inflation".

Another commonly used possibility to construct estimates of the NAIRU is to use the standard Philips-Curve relation (4):

$$(22) \qquad p_t - p_t^e = b(L)(u_{t-1} - NAIRU_t) + d(L)(p_{t-1} - p_{t-1}^e) + g(L)X_t + e_t$$

Where $\pi^{(e)}$ represents (expected) inflation, L is the lag operator and X represents additional regressors included in some empirical specifications. As in the case of the NAWRU-estimates described above there arises the need for a model of inflationary expectations. This specification forces the equilibrium unemployment rate, the NAIRU, to satisfy the steady state condition that expected inflation must equal actual inflation. A drawback of the Philips Curve formulation is that "surprises" of nominal wage inflation (deviations of actual wages from their expected values) have to be treated as nonexistent.

The discussion in Section I indicated that both price setting and wage formation incorporate important information on the development of the NAIRU. It should thus be expected that estimates of the NAIRU can be improved by analyzing both price and wage setting. This can be achieved by combining the wage setting curve (21) with the price setting schedule (23) :

$$(23) \qquad \Delta(\log(p_t) - \log(w_t)) = a_0 - a_1(L)\Delta(\log(w_t - \log(w_t^e)) + a_3\log(y_t) - a_4\log(Z_{p_t}) + e_t$$

where *y* is the level of output market activity and Z_p captures „price pressure“ variables as described in Section I.

An estimate of the NAIRU is then constructed by simultaneous estimation of equations (21) and (23) and solving for unemployment. This method allows to impose homogeneity restrictions both on price setting and on wage formation and thus implies that the estimate of the NAIRU satisfies the necessary conditions for the labour market equilibrium as described in Section I. The estimation of a wage-price system enables us to distinguish between the impact of structural factors on wage formation and price setting respectively.

c) Confidence Margins

Although there exists a great number of empirical estimates of the NAIRU there is an apparent lack of discussion about the precision of these estimates. In fact two fundamental types of uncertainty exist which may contribute to the imprecise measurement of the equilibrium unemployment rate.

The first source of uncertainty arises from the fact that the NAIRU is an unobserved variable which leaves room for a number of plausible empirical models for the measurement of the NAIRU. Different specifications lead in general to different point-estimates of the level of the NAIRU. The exposition above provided an overview about different possible approaches to the measurement of the equilibrium unemployment which concur with the theoretical model of the NAIRU. The most important difficulty in this context arises from the possibility that in the long run the level of the NAIRU may be indeterminate, i.e. that the NAIRU may be stochastic by nature. Three examples might clarify the point.

First Setterfield/Gordon/Osberg (1992) constructed 67 different specifications for the estimation of the NAIRU of the Canadian labour market. Resulting point estimates of the NAIRU were in the range from 4,42% to 9,88%. The main findings of the study point to the significant impact of the length of the estimation period and of the specification of various variables (productivity growth, the model of inflation expectations etc.) on the NAIRU-estimates.

Second Staiger/Stock/Watson (1996) constructed estimates of the NAIRU for the United States, using a variety of different specifications. They report point estimates of the NAIRU for 1990 reaching from 5,55% to 7,37%.

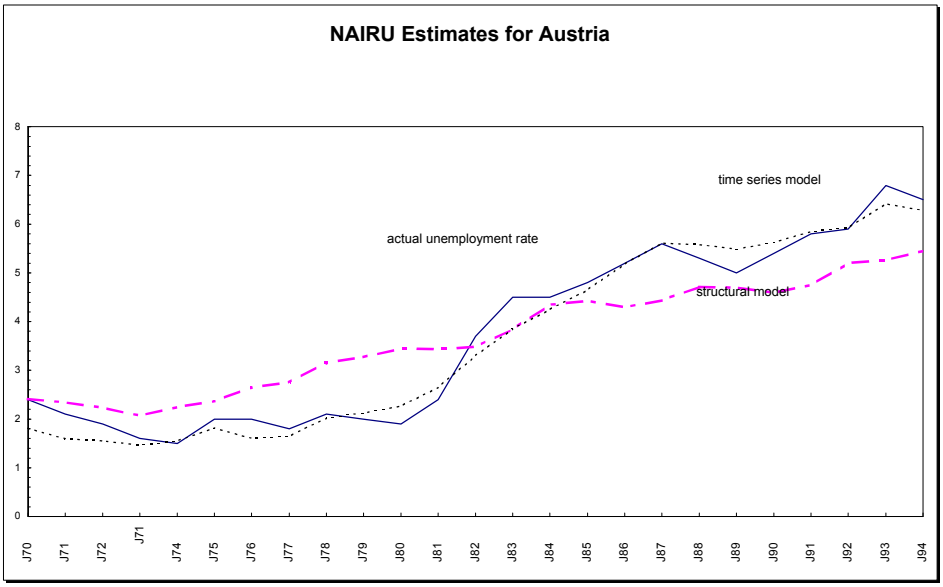
Finally Figure 2 contains two different estimates of the NAIRU in Austria. The "time series model" (Hahn/Rünstler, 1996) represents a NAIRU estimate based on a bivariate Structural Time Series Model for GDP and the unemployment rate. The authors found that according to the best specification the Austrian "equilibrium unemployment" rate follows a smooth stochastic trend.[5]

The "structural model"- estimate (Pichelmann, 1996) results from the simultaneous estimation of a wage-price model of the Austrian labour market (for details see Annex).

The two studies end up with two distinctive conclusions about the nature of the equilibrium unemployment rate. Whereas the time series method leads to the assessment that the long run NAIRU is indeterminate, the structural model supposes that the long run NAIRU can be identified by a limited number of supply side factors. Consequently Figure 1 reveals that the estimates differ significantly not only quantitatively but also with respect to the assessment of the cyclical position of the actual unemployment rate.

[5] Specifically this means that the irregular component i_t and the random walk shock e_t were set to zero according to the structural time series model described in (20). The estimate satisfies the NAIRU condition that it is neutral with respect to inflation.

Figure 2:



The second source of uncertainty stems from the fact that it is impossible to determine the exact values of the parameters using statistical methods. According to all empirical specifications the NAIRU represents a combination of stochastic variables and parameters, leading to imprecision in measurement. Computing confidence intervals for the point estimates of the equilibrium unemployment rates gives an idea on the magnitude of imprecision of conventional methods for the calculation of the NAIRU. Staiger/Stock/Watson (1996) calculated (95% Gaussian) confidence intervals for the NAIRU in the United States. By conducting a sensitivity analysis they showed that Gaussian confidence intervals in fact provide a good description of the uncertainty surrounding the point estimates of the NAIRU. They report that the confidence intervals are at least 2 percentage points around the point estimate of the NAIRU. Moreover these confidence intervals in many cases cover most of the values of observed unemployment rates. From that it follows that in most cases it is not even possible to argue based on the statistical results that the "equilibrium unemployment" rate is different from the actual unemployment rate.

The European Commission (1995) reports (90% Gaussian) confidence intervals for NAIRU estimates of the EU-12 over the period 1972-1994. According to the European Commission the NAIRU of EU-12 was in the range between 2,8%-18,8% in 1994, the point estimate being 6,1%.

III. Conclusions

Undoubtedly the NAIRU concept is a useful way to organize thinking about unemployment and inflation. The NAIRU model provides a simple framework to analyze a broad variety of labour market issues.

A holistic interpretation of the concept ,however, needs to take into account the considerable theoretical complexities involved.

First quite complex adjustment dynamics arise even in simple log-linear wage-price models.

Second the interactions between supply and demand side factors may lead to shifts in the price-wage setting schedules. This can lead to fluctuations of the equilibrium unemployment rate over time.

Given these theoretical complexities serious measurement problems should come as no surprise. The empirical application of the NAIRU concept faces two main impediments: Various empirical studies suggest that results highly depend on model specifications. Furthermore a considerable amount of statistical imprecision is inherent in these results.

For these reasons, policy conclusions drawn from the NAIRU concept must be judged with utmost care, particularly since in many countries a number of labour market measures as well as monetary policy are based on this concept.

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APPENDIX

WAGE FORMATION IN AUSTRIA 1967-1994

A Note

Summary

In this note we use a fairly conventional bargaining framework to analyze aggregate wage formation in Austria. The general specification follows the "Battle of the Mark-Ups" approach as set out e.g. in Layard, Nickell and Jackman (1991). The model has already been applied to Austrian data by Pichelmann (1990) and, here, is simply brought up to date. The main empirical findings derived from econometric estimates of product wage-price equations are

(I) changes in real import prices and indirect taxation have had no significant effect on real labour costs;

(ii) labour productivity enters the wage cost equation with a unitary long-run elasticity;

(iii) the data supports an error-correction model of wage costs with the share of wages serving as error-correction term;

(iv) the elasticity of wages with respect to unemployment is rather high (or, in other words, real wage rigidity is rather low) by international standards; there is, however, evidence for persistence mechanisms in unemployment, as a higher share of long-term unemployed tends to diminish the downward pressure on wages;

(v) a one per cent rise in labour taxes (including social security contributions) is estimated to be associated with a 0.7 to 0.8 per cent increase in labour costs;

We conclude from the analysis that increasing labour taxes, mainly in form of higher social security contributions, and the rising share of long-term unemployed in overall unemployment put upward pressure on real product wages and, thus, have driven up the Austrian NAIRU.

WAGE-PRICE MODEL: 3SLS Estimation Time Range: 1967 - 1994

```
Dependent Variables:  WH   gross product wages per hour
                      PY   producer prices
                      WHPY=WH/PY

Explanat. Variables:  PR   productivity per man-hour
                      UR   unemployment rate
                      SLU  share of long-term unemployment
                      TAX3 indirect taxes
                      TAX2 employers'tax rate on labour
                      OMA. proxy for output market activity

Transformations:      L    logarithmic
                      D    first differences
                      <1>  one period lag
```

PRODUCT WAGE EQUATIONS

```
DLWH = B1*LWHPY<1> + B2*DLPY + B3*DLPY<1> + B4*LHPR<1> + B5*UR
     + B6*UR<1> + B7*DLTAX3 + B8*LTAX2 + B9 + DLWH'WH
```

COEFFICIENT	ESTIMATE	STAND.DEV.
B1	-.38385	.06557
B2	.12827	.10156
B3	.87173	.10156
B4	.38385	.06557
B5	-.02174	.00391
B6	.00950	.00385
B7	-1.00255	.16986
B8	.42569	.23816
B9	-2.02122	.37627

R2=	.96078	R2C=	.94427
DW=	2.27848	RHO=	-.18170
SE=	.00860	MAPE=	8.92601

```
DLWH = B1*LWHPY<1> + B2*DLPY + B3*DLPY<1> + B4*LHPR<1> + B5*UR
     + B6*SLU + B7*DLTAX3 + B8*LTAX2 + B9 + DLWH'WH
```

COEFFICIENT	ESTIMATE	STAND.DEV.
B1	-.41170	.05961
B2	.17352	.10185
B3	.82648	.10185
B4	.41170	.05961
B5	-.01559	.00265
B6	.00099	.00052
B7	-.84481	.14878
B8	.49078	.22350
B9	-2.18056	.34272

R2=	.96538	R2C=	.95081
DW=	2.32442	RHO=	-.23043
SE=	.00799	MAPE=	8.21978

PRODUCT PRICE EQUATION

```
DLPY = B1*LWHPY<1> + B2*DLWH + B3*DLWH<1> + B4*LHPR<1> + B5*OMA1
     + B6*DLOMA2<1> + B7 + DLPY'1
```

COEFFICIENT	ESTIMATE	STAND.DEV.
B1	.44620	.03255
B2	.72465	.08225
B3	.27535	.08225
B4	-.44620	.03255
B5	1.32964	.14799
B6	.04256	.06627
B7	2.31770	.17116

R2=	.82772	R2C=	.77849
DW=	.79377	RHO=	.60793
SE=	.01211	MAPE=	21.31316

UNEMPLOYMENT RATE AND NAIRU

AUSTRIA 1966-1994

Year	unemployment rate (Nat.Def)	NAIRU
1967	2.691	2.063
1968	2.967	2.223
1969	2.796	2.394
1970	2.412	2.415
1971	2.096	2.342
1972	1.937	2.232
1973	1.575	2.068
1974	1.546	2.249
1975	2.066	2.369
1976	2.036	2.649
1977	1.853	2.751
1978	2.100	3.157
1979	2.014	3.270
1980	1.877	3.451
1981	2.424	3.439
1982	3.668	3.482
1983	4.450	3.844
1984	4.538	4.345
1985	4.810	4.426
1986	5.183	4.293
1987	5.576	4.438
1988	5.343	4.709
1989	4.954	4.697
1990	5.358	4.597
1991	5.814	4.750
1992	5.943	5.203
1993	6.782	5.259
1994	6.542	5.455

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